

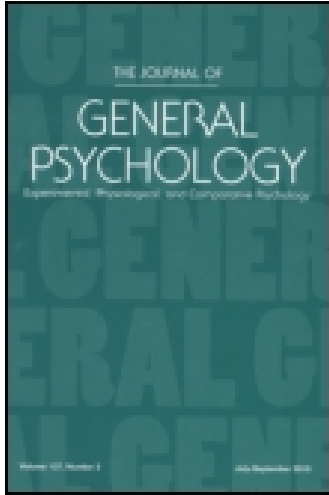
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Publisher: Routledge

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The Journal of General Psychology

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/vgen20>

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B. F. Skinner^{a b}

^a Harvard University, USA

^b Biological Laboratories of Harvard University, USA

Published online: 06 Jul 2010.

To cite this article: B. F. Skinner (1935) A Discrimination Based upon a Change in the Properties of a Stimulus, The Journal of General Psychology, 12:2, 313-336, DOI: [10.1080/00221309.1935.9920107](http://dx.doi.org/10.1080/00221309.1935.9920107)

To link to this article: <http://dx.doi.org/10.1080/00221309.1935.9920107>

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A DISCRIMINATION BASED UPON A CHANGE IN THE PROPERTIES OF A STIMULUS*

From the Biological Laboratories of Harvard University

B. F. SKINNER¹

I

Let two stimuli, $S_{AB..}$ and $S_{AB..L..}$, possessing the same properties except for the property L , elicit a conditioned response R . Then a discrimination may be established by extinguishing the reflex ($S_{AB..}-R$) while continuing to reinforce the reflex ($S_{AB..L}-R$), or *vice versa*. This formulation has been tested experimentally by showing that a curve for the establishment of a discrimination has the principal properties of a curve for extinction (1), but other implications remain to be examined. The problem primarily concerns induction—the mutual influence of two reflexes possessing properties in common—by virtue of which a secondary change in the state of one reflex (such as extinction) cannot take place without affecting the state of the other. The extent of this influence is a function of the degree of community of properties and is therefore inversely a measure of the significance of a differentiating property in defining a stimulus class (cf. 2). In the establishment of a discrimination the inductive influence is attenuated (1).

In this formulation L may be a *stimulus* (having the dimensions of energy), in which case it is added to $S_{AB..}$ as a component member; or it may be a single *property* (a given wave-length or intensity, for example, where S_{AB} is light), in which case it is not capable of independent existence as a stimulus (3). The basis for the discrimination may also be a *duration* or a *change* from one property to another, but in this case a more involved formulation is required. We cannot write “change” and “duration” directly for L on equal terms with “intensity” or “component member” (even after specifying what the change is from and to or the duration measured from), be-

*Accepted for publication by Carl Murchison of the Editorial Board and received in the Editorial Office, July 2, 1934.

¹Society of Fellows, Harvard University.

cause change and duration involve temporal sequences. If we wish to establish a discrimination upon the basis of a change from $S_{AB..}$ to $S_{AB..L..}$, we must show that it is not based upon L alone—that is, that the discrimination is not between $S_{AB..}$ and $S_{AB..L..}$ irrespective of the act of changing from one to the other. In order to do this we must show that $S_{AB..L..}$ is effective immediately after a change from S_{AB} but not otherwise. In other words, we must show a distinction between $S_{AB..L..}$ and $S_{AB..\lambda \rightarrow L..}$ (where λ = absence of L , or some other value where L is a property); and in establishing the desired discrimination we must break down the induction between them. We formulate a “change” by distinguishing between $S_{AB..L..}$ and $S_{AB..\lambda \rightarrow L..}$. The latter expression contains a time factor as required, which need not be more rigorously defined for our present purposes. The case of “duration” is similar but will not be treated in this paper.

II

We begin by breaking down the induction between $S_{AB..L..}$ and $S_{AB..}$, and *vice versa*, in successive discriminations. One set of conditions is maintained until a discrimination is well established and then exactly reversed. We may turn directly to the behavior of the organism under this change.

In the discrimination previously studied (1, 5, 6) a white rat came to respond to a lever by pressing it downward whenever a light was present (when the response was reinforced with food) but not to respond in the absence of the light (when the response was not reinforced). We describe this as the extinction of ($S_{AB..}—R$) and the concurrent reinforcement of ($S_{AB..L..}—R$). If we reverse this discrimination, the responses in the absence of the light are reinforced and those in the presence of the light are not. The behavior of the rat during the change may be studied with the method of periodic reconditioning already described, for details of which the reader is referred to an earlier paper (1). The procedure for a single day may be outlined as follows. Originally the light is on at the release of the rat and the first response is reinforced. The light and the food-magazine are then turned off, and the succeeding responses to $S_{AB..}$ are not reinforced. When the discrimination has become well advanced, very few responses occur in the absence of the light. At the end of the interval (five, or in the first of the fol-

lowing experiments six, minutes) both light and magazine are turned on. The rat responds after a latency of the order of five or six seconds (see below), and the response is reinforced. The light and magazine are then turned off for another interval and this is repeated for one hour, at the end of which the rat is removed from the apparatus until the following experimental day. *On the day of reversal* the first response is in the dark and is reinforced; the light is then turned on for five (or six) minutes and no response is reinforced. The light is then turned off, the next response reinforced, and the light turned on again; and this procedure is repeated for one hour. All responses are recorded automatically in the form of number-*vs.*-time graphs.

From information already available we can predict the principal aspects of the behavior of the rat on the day of reversal. We know that after the development of a discrimination an extinction curve displaying certain characteristic properties will be obtained if the previously reinforced stimulus ($S_{AB..L..}$) is presented continuously without reinforcement (5). If we disregard the short periods of $S_{AB..}$ (no light) which occur every five or six minutes we should expect an extinction curve at the beginning of the day of reversal. Such a curve need not have so great an area as a curve for original extinction (5). We also know that periodic reinforcement of the previously extinguished member ($S_{AB..}$) will produce a return to the original strength under periodic reconditioning (5). Third, we know that curves of these two sorts sum algebraically when the conditions for their development exist simultaneously. This was reported without data in (1, footnote, p. 324). A typical curve is shown in Figure 1. It was obtained when a rat in which the response to the lever had been well conditioned was transferred directly to the procedure of periodic conditioning without previous extinction. The first part of the curve is for the extinction of the reflex and shows what we may interpret, on the basis of previous experiments, as a cyclic deviation within a logarithmic envelop, which has been indicated with a dotted line. During the development of this curve, the reflex is being reconditioned at intervals of five minutes, and a curve of positive acceleration approaching a constant high slope should appear (1). The experimental record shows the emergence of this curve, which cuts across the curve for extinction and sums

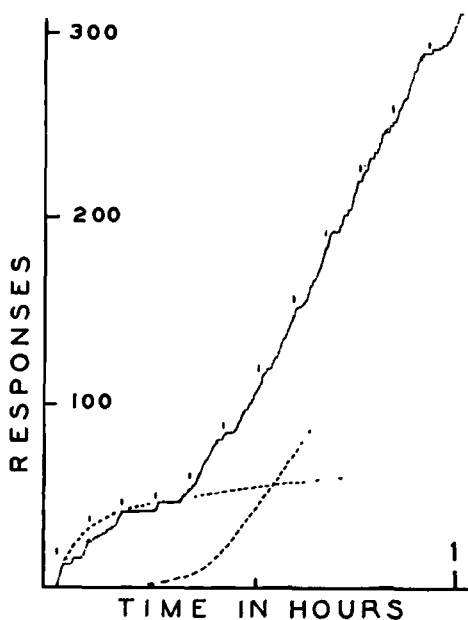


FIGURE 1

with it. The inferred course of the second curve is indicated with a dotted line to demonstrate the summation. The dotted curves are not offered as a quantitative analysis.

We should expect a compound curve of this sort on the day of reversal, but with one modification. The curve of positive acceleration should approach, not a constant slope, but the curve of negative acceleration along which the new discrimination is to develop. In Figure 1 no discrimination is possible, since it is for simple periodic reconditioning. In the present case a discrimination is expected. The resulting curve should therefore be composed of at least three separate parts, and in spite of its complexity it is actually obtained experimentally.

A group of eight male rats, approximately 110 days old at the beginning of the experiment, were put through the procedure for discrimination with an interval of reconditioning of six minutes. On the eighth day of the discrimination the conditions were reversed.

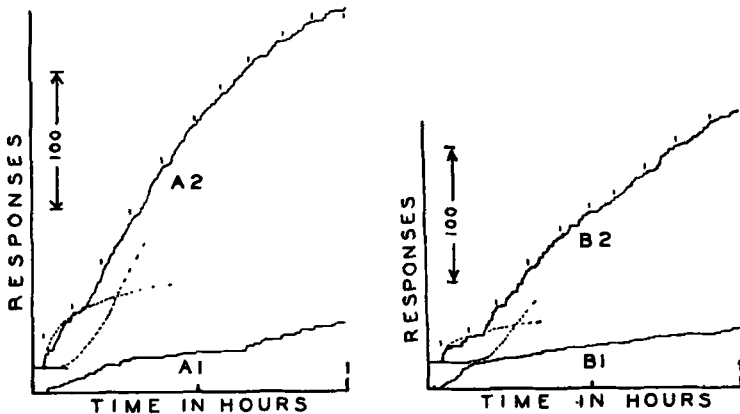


FIGURE 2

Two records for the day of reversal are given in Figure 2. The records *A1* and *B1* are for the seventh day of the discrimination. Those marked *A2* and *B2* are for the day of reversal, and show the predicted characteristics. They begin with extinction curves, but curves of positive acceleration cut through these and lead to negative accelerations as the new discriminations develop. These are typical records. The result may be less clear when the rate fails to return to its full value under periodic reconditioning (two out of eight cases in the present experiment) but from the nature of these exceptions (see below) they should not affect the present argument.

Four typical records for the whole process are reproduced in Figure 3. They are obtained by plotting the end points of the daily records and copying the intervening records free-hand. The first three days in the figure are for periodic reconditioning at six-minute intervals. On the fourth day (at the vertical broken line) the discriminatory procedure was begun, and the next seven days show the development of the discrimination. The minor deviations in these records resemble those previously reported (1). The daily records *A1* and *B1* in Figure 2 are shown by brackets in the present figure. At the second broken line the conditions were reversed. The detailed records *A2* and *B2* in Figure 2 are also bracketed. In the other two curves the return to the periodic slope is slower and never

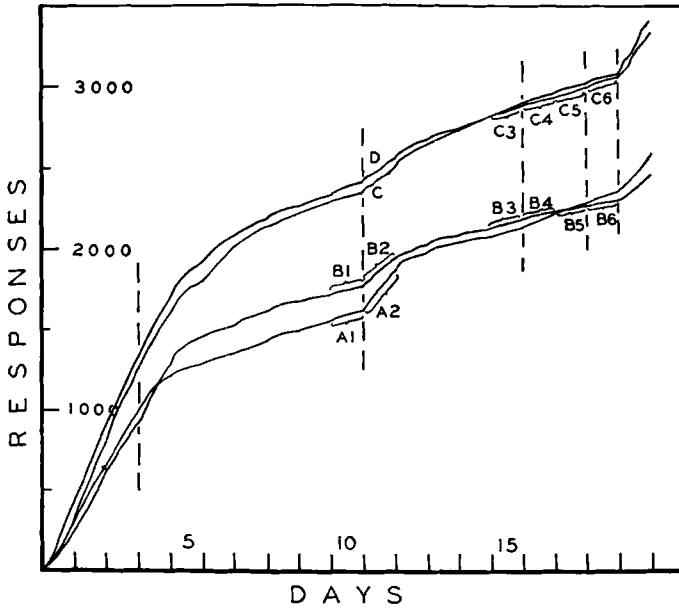


FIGURE 3

becomes fully developed, but the characteristics of the records for reversal are apparent in spite of the considerable reduction required by the figure. The following five days show the development of the second discrimination, at the end of which the rate of elicitation of the extinguished member ($S_{A.B..L..-R}$) has reached a low value. (As we shall note again later, it is not as low as at the end of the first discrimination.)

In order to understand this second curve we must consider an experiment involving an original discrimination in which no previous periodic reconditioning takes place. Four rats were conditioned to the lever in the presence of the light and the responses were then extinguished both in the light and in the dark. The rats were then transferred directly to the discriminative procedure without the usual three or four daily hours of periodic reconditioning. A typical set of records is reproduced in Figure 4. The first record shows some upward convexity at the beginning, which is due to "loss of extinc-

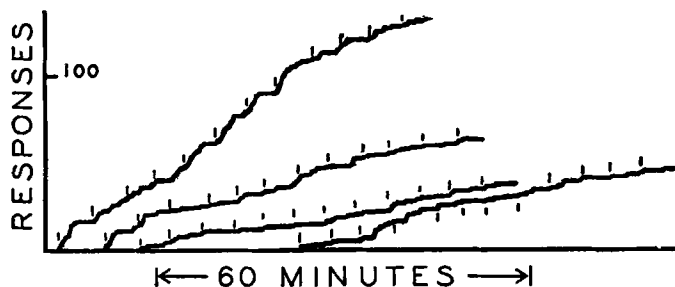


FIGURE 4

tion" (4). There is then a quite significant acceleration, and a subsequent decline in rate. The next three days show the usual development of a discrimination. The fourth record shows a slight burst of activity shortly after the start and the total for the day is consequently high; but these are incidental factors that have already been described as characteristic of the process (1). The complete sets for all four rats and their average (the heavy line) are given in Figure 5; the series from Figure 4 is marked *D*.

The fairly high rate developed on the first day in this simple experiment is for ($S_{AB..}-R$), which has never been reinforced. The strength which it develops must be due to induction from the reinforcement of ($S_{AB..L..}-R$). Part of the effect is the result of the

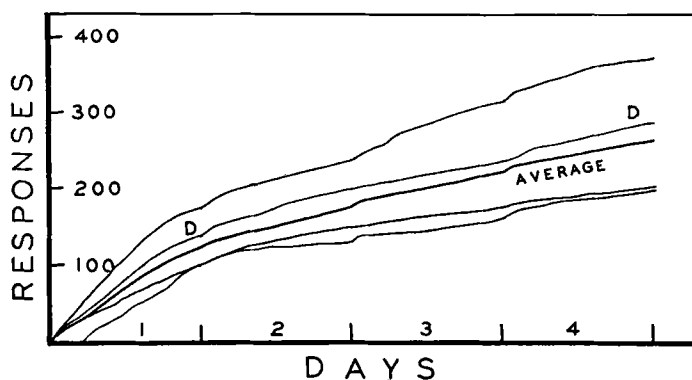


FIGURE 5

original conditioning, which is reflected in the "loss of extinction" at the beginning of the first records. That is to say, the extinction of both $(S_{AB..}—R)$ and $(S_{AB..L..}—R)$ has not wholly eliminated the inductive effect upon $(S_{AB..}—R)$ of the original conditioning of $(S_{AB..L..}—R)$. The *positive* acceleration in the first record in Figure 4 is due, on the other hand, not to a loss of extinction, but to the concurrent periodic reinforcement of $(S_{AB..L..}—R)$.

This is not exactly the sort of curve that we should expect to find after reversal of a discrimination, but it is very close to it. What appears in Figure 4 as "loss of extinction" is original extinction in Figure 2. But both curves exhibit positive acceleration and for the same reason—induction due to the concurrent periodic reinforcement of a related reflex. The negative acceleration is in both cases the beginning of a discrimination. The only characteristic here important is that the curves in Figure 5 inclose a much smaller area than the first curves in Figure 3 or than any curve for discrimination after periodic reconditioning, other conditions being equal. For a similar reason we should not expect the area of the curve for discrimination *after reversal* to resemble that of the original curve. The original curve includes the extinction of the effect of three hours of periodic reconditioning; the reversed curve includes, in addition to the extinction of $(S_{AB..L..}—R)$, only as much of an inductive effect as can take place before the new discrimination becomes effective.² Since the areas are not comparable, the most significant effect of the reversal is the shape of the records for the first day, which reveals clearly enough the nature of the change taking place.

III

But there is another important effect of reversal—upon the state of the reinforced reflex. The records of the rate of responding that we have considered supply information only about the unreinforced member. The reinforced responses occur at regular intervals and contribute to the records only a low constant slope, which could be subtracted if we wished, but which we are disregarding. Significant information about the reinforced member may be obtained,

²A study of a discrimination beginning *ab initio*, without previous conditioning of either stimulus, will be published elsewhere (6). The result is in agreement with the present interpretation of a discrimination without periodic reconditioning.

however, from its latency, which is measured (in the present case to the nearest second) as the interval elapsing between the introduction of the light and the appearance of the response.

Before the original discrimination develops, the value of this latency is determined by the basic rate under periodic reconditioning (1, Appendix III). At the beginning of the discrimination the latency drops rapidly to a value of the order of six or seven seconds (the individual differences being rather large). A nearly minimal value may be reached within four or five reinforcements, but since the interval depends at the start on accidental factors, it is difficult to trace the course of this change. The average latency for the first day of the discrimination (comprising either nine or eleven reinforcements depending upon whether the interval is six or five minutes) is already well below the average value obtaining under periodic reconditioning. There is a slower daily fall thereafter, which may persist in some slight degree as long as the experiment is carried on (for at least 30 days).

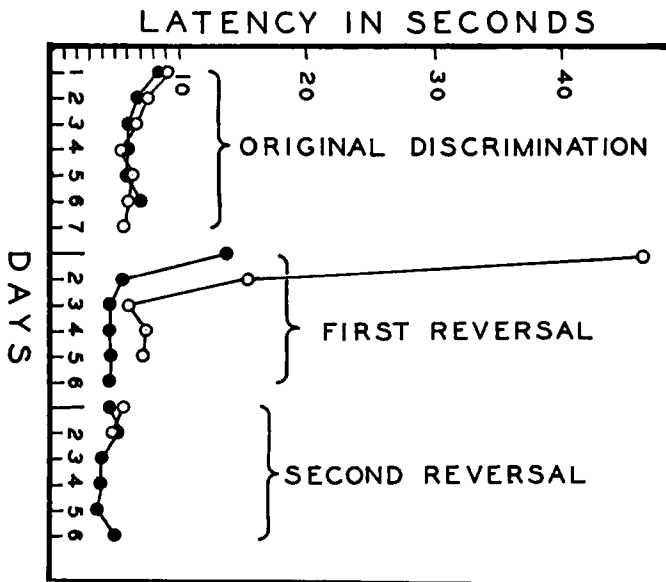


FIGURE 6

The average latencies for the eight rats in the present experiment (nine latencies per rat per day) are represented by the open circles in Figure 6. The series for the original discrimination [latencies for ($S_{AB..L..}-R$)] begins at the already reduced value of 9.2 seconds. A significant drop is to be observed during the following two or three days. After the reversal the latency is measured for ($S_{AB..}-R$), which has previously been extinguished and is therefore at a very low strength. The latency begins, consequently, at an extremely high value. The average for the first day is 46.0 seconds. The reconditioning is slow, and the effect of the previous extinction is still apparent on the second day where the latency has fallen only to 15.5 seconds. On the third day, however, the strength reaches approximately the value held by ($S_{AB..L..}-R$) in the original discrimination and continues approximately at that value thereafter.

IV

If we now reverse the discrimination a second time, we return, of course, to the original set of conditions. There seems to be no reason to expect *a priori* that this will not involve another complex curve of the type already obtained. ($S_{AB..}-R$) has now been reconditioned and should be extinguished, although the curve for extinction might be considerably smaller (4, 5). ($S_{AB..L..}-R$) is at a low strength and should return to essentially its strength under periodic reconditioning. The experimental result, however, which is so far without exception, shows no effect of a second reversal. In the present experiment the reversal was made after the new discrimination had been in force for five days. Two pairs of records for the days immediately before and after the second change are given in Figure 7, and their position in Figure 3 is indicated by brackets. It is apparent in comparing these records with Figure 2 that there is no initial increase in rate on the day of reversal that could be regarded as an extinction curve for ($S_{AB..}-R$) nor is there any positive acceleration with subsequent decline in rate. Some slight effect appears if we average the total number of responses per hour for all eight records. The averages for the three days prior to the second reversal and the two days following it are as follows:

.....96, 92, 88 | 95, 79.....

Toward the end of the discrimination the slope was falling at the

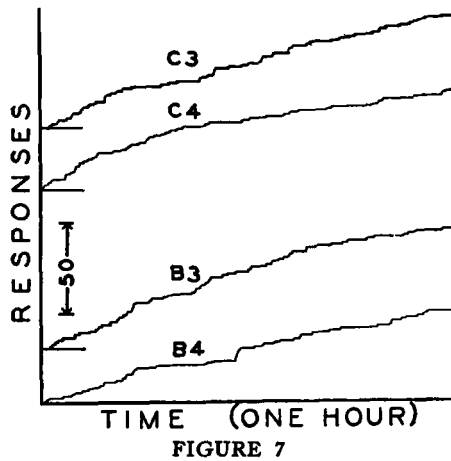


FIGURE 7

rate of about four responses per hour. On the day of reversal there was an increase of seven responses (eleven above the expected number), but on the second day the rate had dropped to approximately what it would have been without reversal. The only significant change, then, (if this is really to be taken as significant), is a slight increase in rate, apparently distributed evenly throughout the hour.

Similarly there is no change in latency comparable with that observed upon a first reversal. This is apparent in Figure 6 where the latencies are given for two days after the second reversal. (There is an apparent omission of a day at the end of the second series because the graph has been spaced out to accommodate a second set of data to be described shortly. The three series were taken continuously.) It will be seen that the rise in latency at the first reversal has no counterpart at the second.

Upon changing the conditions a third time (returning now to the reversed set) we again obtain no effect, as shown at the fourth vertical line in Figure 3. Two pairs of records are given in Figure 8 and their positions in the series are indicated in Figure 3 as before. The number of responses on the day of the third reversal was 76, which follows perfectly in the declining series given above. The latency also undergoes no significant increase, although this is not shown in the figure.

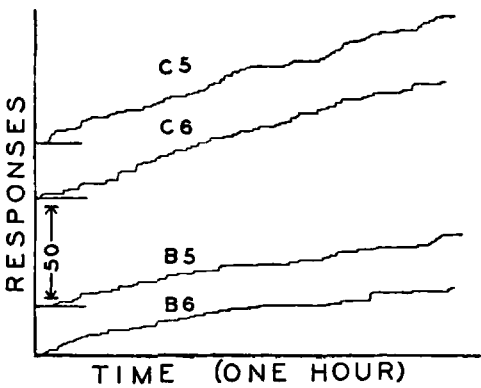


FIGURE 8

At the end of the experiment a check was made against a possible decline in rate for some unknown reason by returning to simple periodic reconditioning. The recovery of a constant slope is shown on the last day of Figure 3. It is clear that a significantly high strength is quickly developed. The average slope is not, however, equal to that originally observed, and it is in general true that after prolonged discrimination the acceleration toward the normal slope under periodic reconditioning is retarded. We have already seen examples of this in records *C* and *D* in Figure 3, although the effect might there have been due to the reversal. Four other cases, obtained after a long series of discriminations to be described shortly, are given in Figure 9. A typical curve (*K*) for return to the

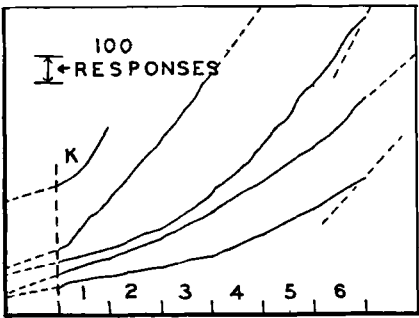


FIGURE 9

periodic slope after a short discrimination is included on the same coordinates [the original curve is reproduced in (5) Figure 2]. The broken lines at the beginning give the slopes reached at the end of the discrimination. Those at the end give the original slopes under periodic reconditioning. It will be seen that only one of the four rats reaches its original slope on the first day. The others show fairly smooth but greatly retarded accelerations, and one at least has not reached the required slope by the end of the sixth day.

V

In accounting for the difference between the effects of a first and a second or third reversal, a partial explanation may be drawn from information already at our disposal. So far as the first limb of the curve (Figure 2, records *A2* and *B2*) is concerned, it has been shown that extinction after discrimination may yield a smaller curve than original extinction (5), and it is not unreasonable to suppose that a second curve would average no more than seven responses in one hour and that a third would be negligible. The absence of a positively accelerating limb may be referred to the retardation in Figure 9 and to the assumption that, if the acceleration can be put off until a new discrimination has developed, it will not occur. But these explanations are obviously labored, if not definitely inadequate. It is clear that a second reversal differs from the first in a special way, and if we define the process of discrimination rather narrowly as the breakdown of induction, we can distinguish between them by saying that at the second reversal a new discrimination is not established.

This might reasonably have been expected. We have already destroyed the inductive effect of ($S_{AB..L..}-R$) upon ($S_{AB..}-R$), at least to the degree given by the slope of the discrimination curve when it was brought to an end. That this has not affected the reciprocal effect of ($S_{AB..}-R$) upon ($S_{AB..L..}-R$) is obvious from the result of the first reversal; the reciprocal induction must be broken down separately. But we have no reason to suppose that during this second process, the result of the first will be undone. [Indeed, it is not apparent how induction can possibly be affected in a positive direction, except through a (relatively slow) spontaneous recovery.] Accordingly, when we reverse the conditions a

second time, we return to a discrimination that has already been established and no further change is needed.

But the assumption that the breakdown of induction is irreversible will not wholly account for our present observations. Granted its validity, we should still expect a second reversal to produce (a) the extinction of the previously reinforced member (observed as a small extinction curve on the day of reversal) and (b) the reconditioning of the previously unreinforced member (observed as a shortening of its initially long latency). The requirement of a small extinction curve is approximately satisfied by our eleven extra responses at the second reversal, but not at later reversals, and the requirement of an initially long latency with subsequent reduction is not satisfied in any case after the first reversal. Thus in Figure 6 we have already seen that no significant increase in latency accompanies a second reversal. This is true not only of the average for the hour but of the first few reinforcements. In another series of experiments (to be described shortly) a reversal was made in the middle of the hour in order to show the simplicity of this change. Four typical records showing three successive days for each rat are given in Figure 10. The upper record in each group shows the last day of a discrimination in which $S_{AB..}$ is being reinforced, the middle record shows the first day of (a third) reversal, and the lower record a continuation of the reversed discrimination until the middle of the hour, when the conditions were reversed again. On this last day the light was turned on as usual before the reinforced response at the vertical line. It was then *left on* for the succeeding interval. When it was turned off again a response followed immediately, and it was then turned on. During the rest of the hour $S_{AB..}$ was periodically reinforced. The records show no significant change correlated with this reversal. The average latencies for eight rats for the eleven reinforcements during the hour (omitting the reinforcement at release) are as follows:

6.0, 3.4, 5.3, 5.6, 3.0, | 6.4, 4.4, 5.7, 7.0, 5.4, 5.0

The latency of 6.4, for the first discriminatory response after reversal, cannot be taken as significantly above the average.

A more crucial experiment on this point was made with the same

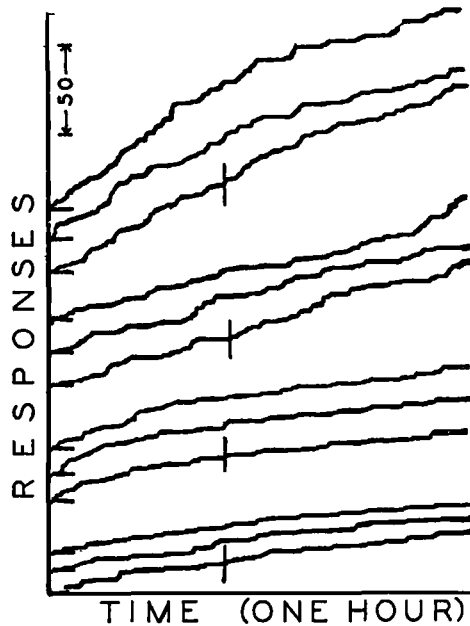


FIGURE 10

eight rats on a later day, when the conditions of the discrimination were changed at every interval during the hour. At release the light was on and the first response reinforced; the light was left on for five minutes, then turned off. A response immediately followed. The light was left off for five minutes, then turned on, when another response followed—and so on. In one group of four rats the average latency for the hour was 5.1 seconds as compared with five seconds for the previous day under normal discriminatory conditions. In the other group the latency was seven seconds as compared with five seconds on the previous day. The increase in the latter case was due to five especially long latencies (averaging about 25 seconds each) which appeared anomalously in the records of two of the rats. While they are probably significant, they do not seriously affect the present conclusion, which is that an increase in latency such as would be required by a theory of rapid reconditioning at each new discrimination is not observed. Similarly the slopes

of the eight records show no effect of extinction, such as would also be required; the averages for the two days prior to the day of repeated reversal were 135 and 116 responses respectively. On the day of reversal the average was 110 responses. (These relatively high values are due to the late stage of the experiment. As we have already noted, the slopes approached by later discrimination curves progressively increase.)

VI

In accounting for this experiment we reach at last the point of the present paper. It is obvious that at a second reversal and thereafter the effective basis for the discriminatory response is the *change* from either stimulus to the other. The observed fact is that both $S_{AB.. \lambda \rightarrow L..}$ and $S_{AB.. L \rightarrow \lambda..}$ are effective stimuli, while $S_{AB.. L..}$ and $S_{AB..}$ are ineffective. This is the condition that we originally wished to set up in making a change the effective basis for a discrimination, and our only remaining problems are to explain, first, why the condition is found already established at the second reversal and, second, why there is no inductive influence of $(S_{AB.. \lambda \rightarrow L..} - R)$ upon $(S_{AB.. L..} - R)$ nor of $(S_{AB.. L \rightarrow \lambda..} - R)$ upon $(S_{AB..} - R)$ —or, in other words, why the discriminations between $S_{AB.. \lambda \rightarrow L..}$ and $S_{AB.. L}$ and between $S_{AB.. L \rightarrow \lambda..}$ and $S_{AB..}$ are found already in existence after discriminations between $S_{AB.. L..}$ and $S_{AB..}$ have been set up in both directions.

The first point is not difficult. In the original discrimination the reinforced response is really to $S_{AB.. \lambda \rightarrow L..}$ (if we are now to make this distinction throughout). The extinction, on the other hand, is of the responses to S_{AB} , not $S_{AB.. L \rightarrow \lambda..}$, since the rat is eating for at least 15-20 seconds after the change back to $S_{AB..}$ is made. After the first reversal $(S_{AB.. L \rightarrow \lambda..} - R)$ is periodically reinforced and $(S_{AB.. L} - R)$, *not* $(S_{AB.. \lambda \rightarrow L..} - R)$, is extinguished. The second of the responses to S_{AB} , not $S_{AB.. L \rightarrow \lambda..}$, since the rat is eating for reversal therefore finds $(S_{AB.. \lambda \rightarrow L..} - R)$ and $(S_{AB.. L \rightarrow \lambda..} - R)$ previously reinforced and not subsequently extinguished, and $(S_{AB..} - R)$ and $(S_{AB.. L..} - R)$ extinguished and not subsequently reinforced, which is the required condition.

The second point, the lack of induction, is apparently not to be accounted for on any previously established principle. We may leave

it, therefore, in the form of a descriptive statement as one of the results of the present study: with the present technique, in which reinforcement occurs very soon after presentation of the stimulus, it is possible to obtain a discrimination based wholly upon a change (as we here define it) by exhausting possible discriminations between the stimuli themselves.

[That a stimulus can depend upon the temporal proximity of another stimulus for its effectiveness has already been shown (1). No significant difference as a discriminative component was found between a light which remained on during reinforcement and a sound which was presented *before* reinforcement but never simultaneously with it. If we write the sound as $S_{AB.. \lambda \rightarrow L \rightarrow \lambda..}$, its relation to the present "change" will appear. A different formulation is required in the case of the change because of other possible bases for the discrimination.]

VII

In another series of experiments an attempt was made to separate the factors in the curves for the day of reversal by interpolating a day of periodic reconditioning. The records for a group of eight male rats (90 days old at the start) have been averaged to give the lower curve in Figure 11, in which the average curve for the

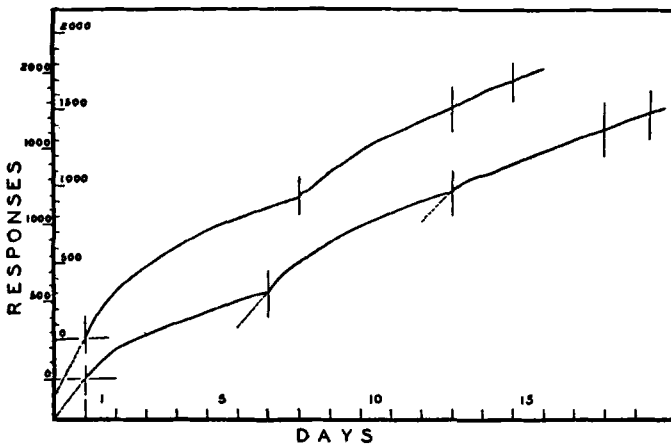


FIGURE 11

eight rats in the preceding experiment is also given. To aid the comparison the interpolated days of periodic reconditioning have been omitted from the main curve and inserted beneath the last days of the preceding discriminations.³ To go over the curve in detail—the first day shows the average slope for the last of four days of periodic reconditioning (of $S_{AB..-R}$) at intervals of five minutes. [The slope is somewhat less than for the other group. Individual variation—in the ratio N_e/N_c (1)—is great enough to account for differences in the averages of small samples, but we may also appeal to slight differences in methods of feeding, in health, atmospheric conditions, and so on, which may vary to some extent from one experiment to another although they remain practically constant during a single experiment.] The following six days of the figure show the development of a discrimination, ($S_{AB..-R}$) being extinguished. On the seventh day $S_{AB..L..}$ is present continuously, and responses to it are periodically reinforced; the recovered slope is indicated with a broken line on the sixth day of the figure. The separate records resemble Figure 1⁴ the positive acceleration approaching a straight line. The total slope is somewhat less than that observed before discrimination, but this is mainly due to the time required for acceleration rather than to the retarded acceleration noted above. The reversed discrimination begins on the following day from the new periodic slope, and is well developed at the end of six days. Another day of periodic reconditioning (of $S_{AB..-R}$) follows, and the resulting slope is shown with the broken line on the twelfth day. The retarded acceleration is now beginning to be felt.

This second interpolated day of periodic reconditioning forces the reconditioning of ($S_{AB..-R}$), which could not occur in the first experiment because of the lack of induction. Accordingly, when the discrimination is reversed again, a significant increase in slope is observed. The average number of responses for the three days prior

³Broken lines give average slopes only. No attempt has been made to show the initial positive acceleration.

⁴All records of periodic reconditioning, particularly on the first day, are subject to chance variations depending upon whether or not the rat responds soon after the magazine has been turned on. If it does not (and this is not under our control) an orderly periodic reinforcement is, of course, impossible. Only rarely is the general course of the record obscured.

to the day of periodic reconditioning, the average for the latter (in parentheses), and the average for three days of the new discrimination are as follows:

85, 72, 62 | 192 | 99, 85, 80

The extra responses after reversal are chiefly due to the periodic reconditioning of ($S_{AB..}-R$) on the interpolated day. That they are not supplemented by any considerable induction from ($S_{AB..L..}-R$)—that no new discrimination is taking place—is clear from the quick adjustment to a constant slope, though this slope, as we have already noted, is increased by the reversal.

The average latencies for this series of experiments are given as the solid circles in Figure 6. There is a significant increase at the first reversal, as before, but none at the second. The increase at the first is much less than in the previous experiment, but this can reasonably be regarded as the effect of the day of periodic reconditioning.

As a control, the conditions were reversed a third time without returning to the periodic slope. The result is shown in Figure 11 at the fourth vertical line and fully confirms the previous finding. On the following day the conditions were reversed in the middle of the hour as already described (Figure 10).

Figure 11 shows very well the progressively higher slope approached by successive discrimination curves. If we combine this phenomenon with the retardation of acceleration shown in Figure 9, we may describe both changes together as a tendency toward stabilization at a mean rate. The significance of this change is not at present apparent. It does not seriously interfere with the present conclusions.

VIII

An experiment of this sort must be controlled against the possibility that a discrimination in which the reinforced member is $S_{AB..L..}$ may differ significantly from one in which it is $S_{AB..}$. Otherwise the effect of the first reversal may in part be due to a change in the kind of process. In the present case the control was supplied by dividing the animals between the two types. Half the cases reported above were actually of the opposite sort, and in these

cases L should be read λ and *vice versa*. In Figures 2, 4, 5, and 10 all records were as described. In Figure 3 the two lower curves were as described, the two upper were the opposite; the apparent correlation, which is deceptive, is due to the periodic slope which happened to be greater in the latter case. In Figures 6 and 11 each point or curve represents an equal number of records of each type. The cases of Figures 7 and 8 can be found from Figure 3.

No significant difference is to be observed between the two cases which is great enough to disturb the present conclusions. The eight cases in the lower curve in Figure 11 are convenient for comparison because each case includes three discrimination curves of equal length (six days). Sorting these 24 curves into the two kinds and averaging, we obtain Figure 12. The broken lines are for the slopes under periodic reconditioning. In the curve A the light was off during periodic reconditioning and during most of the discrimination—that is, $(S_{AB} \rightarrow R)$ was the extinguished member. In B the opposite was true. The difference between the curves is mainly attributable to the difference in the initial periodic slopes. There is no significant effect upon latency. Where the change prior to reinforcement was $L \rightarrow \lambda$, the latency was 5.86; where it was the opposite, the latency was 5.39.

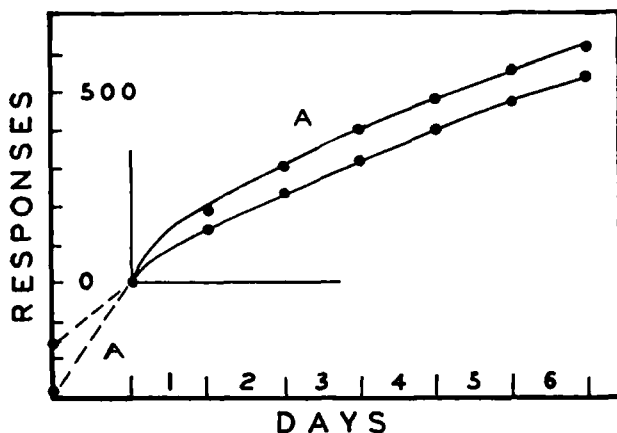


FIGURE 12

SUMMARY

1. A change in the properties of a stimulus may be formulated by writing the stimulus to which the change is made (say, $S_{AB..L..}$) and adding an expression for the temporal proximity of the stimulus from which it is made (giving $S_{AB..\lambda \rightarrow L..}$, where λ = the absence of or some other value of the property L). A discrimination based upon the change alone must be between $S_{AB..\lambda \rightarrow L..}$ and $S_{AB..L..}$ or between $S_{AB..L.. \rightarrow \lambda..}$ and $S_{AB..}$ and requires for its demonstration the elimination of possible discriminations between $S_{AB..L..}$ and $S_{AB..}$.

2. A discrimination between $S_{AB..L..}$ and $S_{AB..}$ is first established, the response to the latter being extinguished. The conditions are then exactly reversed. The result is that ($S_{AB..L..}-R$) is extinguished, ($S_{AB..}-R$) is reconditioned, and a discrimination in the opposite direction is set up. The experimental curve for the day of reversal gives the resultant of these three processes.

3. The effect of reversal upon the latency of the reinforced reflex is also reported.

4. When the conditions are reversed a second time there is no comparable change in either rate of responding or latency.

5. This can be partly accounted for by assuming that the breakdown of induction which characterizes the process of discrimination is irreversible. But on this assumption each reversal will require reconditioning of the previously extinguished member and extinction of the previously conditioned. No significant evidence of these effects is found in crucial experiments.

6. The following interpretation is therefore demanded. At a second reversal, and thereafter, the effective stimuli are $S_{AB..\lambda \rightarrow L..}$ and $S_{AB..L..\lambda..}$, while $S_{AB..L}$ and $S_{AB..}$ are not effective. That is to say, we have a discrimination between the stimuli which involve the temporal proximity of other stimuli and the same stimuli lacking that proximity. But this is our original formulation of the way in which a "change" can become the effective basis for a discrimination.

7. A confirming experiment is reported in which interpolated days of periodic reconditioning are used to separate out the several factors operative on the days of reversal.

8. A control against a possible difference in the discriminations between $S_{AB..L..}$ and $S_{AB..}$ and *vice versa* is described.

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*Harvard University
Cambridge, Massachusetts*

UNE DISCRIMINATION BASÉE SUR UN CHANGEMENT DANS LES PROPRIÉTÉS D'UN STIMULUS

(Résumé)

1. On peut formuler un changement dans les propriétés d'un stimulus au moyen d'écrire le stimulus *auquel* le changement est fait (par. ex. $S_{AB..L}$) et d'ajouter une expression pour la proximité temporelle du stimulus *duquel* il est fait (ce qui donne $S_{AB..L} \rightarrow L..$, ou $L =$ l'absence ou une autre valeur de la propriété L). Il faut qu'une discrimination basée sur le changement seul soit entre $S_{AB..L} \rightarrow L..$ et $S_{AB..L..}$ ou entre $S_{AB..L} \rightarrow L..$ et $S_{AB..}$ et elle exige pour sa démonstration l'élimination des discriminations possibles entre $S_{AB..L..}$ et $S_{AB..}$.

2. Une discrimination entre $S_{AB..L..}$ et $S_{AB..}$ est premièrement établie, la réponse à la dernière étant éteinte. Les conditions sont ensuite exactement renversées. Le résultat est que $(S_{AB..L..} - R)$ est éteinte, $(S_{AB..} - R)$ devient de nouveau conditionnelle, et une discrimination est établie dans la direction contraire. La courbe expérimentale pour le jour du reversement donne le résultat de ces trois processus.

3. On rapporte aussi l'effet du reversement sur la latence du réflexe renforcé.

4. Quand les conditions sont renversées une seconde fois, il n'y a aucun changement comparable dans la vitesse de la réponse ou dans la latence.

5. On peut expliquer ceci en partie, en supposant que l'écroulement de l'induction lequel caractérise le processus de la discrimination ne soit pas renversible. Mais avec cette supposition chaque reversement exigera que le membre antérieurement éteint soit de nouveau conditionnel et que le membre antérieurement conditionnel soit éteint. On ne trouve aucunes évidences de ces effets dans des expériences définitives.

6. On exige donc l'interprétation suivante. A un deuxième renversement et après, les stimuli effectifs sont $S_{AB...L} \rightarrow L$ et $S_{AB...L} \rightarrow \lambda...$. Mais $S_{AB...L...}$ et S_{AB} ne sont pas effectifs. C'est-à-dire, on a une discrimination entre les stimuli ou il s'agit de la proximité temporelle d'autres stimuli et les mêmes stimuli qui n'ont pas cette proximité. Mais ceci est notre formulation originale de la méthode selon laquelle un "changement" peut devenir la base effective pour une discrimination.

7. On rapporte une expérience de confirmation où les jours interpolés du conditionnement nouveau périodique sont employés pour séparer les plusieurs facteurs qui opèrent les jours du renversement.

8. On décrit un contrôle contre une différence possible dans les discriminations entre $S_{AB...L...}$ et $S_{AB...}$ et *vice versa*.

SKINNER

EINE UNTERSCHIEDUNG, DIE AUF EINER VERÄNDERUNG DER EIGENSCHAFTEN EINES REIZES BERUHT

(Referat)

1. Eine Veränderung der Eigenschaften eines Reizes kann durch das Schreiben des Reizes, auf den die Veränderung folgt (z. B. $S_{AB...L...}$) formuliert werden, und durch den Zusatz eines Ausdrucks für die zeitliche Nähe des Reizes, von der er gegeben wird ($S_{AB...L} \rightarrow L...$, wo λ die Abwesenheit der Eigenschaft oder irgendeinen anderen Wert dieser Eigenschaft bedeutet). Eine Unterscheidung, die auf der Veränderung allein beruht, muss zwischen $S_{AB...L} \rightarrow L...$ und $S_{AB...L...}$ oder zwischen $S_{AB...L} \rightarrow \lambda$ und $S_{AB...}$ sein und erfordert zu ihrem Beweis die Ausschaltung der möglichen Unterscheidungen zwischen $S_{AB...L...}$ und $S_{AB...}$.

2. Eine Unterscheidung zwischen $S_{AB...L...}$ und $S_{AB...}$ wird zuerst festgesetzt, die Antwort auf die letztere wird ausgeschaltet. Die Zustände werden dann genau umgestellt. Die Folge davon ist, dass ($S_{AB...L...} - R$) ausgeschaltet, ($S_{AB...} - R$) wiederbedingt, und eine Unterscheidung in der umgekehrten Richtung aufgestellt wird. Die experimentelle Kurve für den Tag der Umstellung gibt die Resultante dieser drei Vorgänge.

3. Die Wirkung der Umstellung auf die Verborgenheit des verstärkten Reflexes wird auch angegeben.

4. Wenn die Umstände zum zweiten Mal umgestellt werden, gibt es keine vergleichbare Veränderung, weder in der Schnelligkeit der Antwort noch in der Verborgenheit.

5. Dies kann teilweise durch die Annahme erklärt werden, dass der Zusammenbruch der Induktion, der den Vorgang der Unterscheidung charakterisiert, nicht umkehrbar sei. Aber bei dieser Annahme wird jede Umstellung das Wiederbedingen des vorher ausgeschalteten Mitglieds und das Auslöschen des vorher Bedingten erfordern. Kein bedeutsamer Beweis für diese Wirkungen kann durch kritische Experimente nachgewiesen werden.

6. Die folgende Deutung wird daher verlangt. Bei einer zweiten Umstellung und nachdem sind die wirksamen Reize $S_{AB...L} \rightarrow L$ und $S_{AB...L} \rightarrow \lambda...$. Aber $S_{AB...L...}$ und $S_{AB...}$ sind nicht wirksam. Das heisst,

wir haben eine Unterscheidung zwischen den Reizen, die von der zeitlichen Nähe der anderen Reize und derselben Reize, die jener Nähe ermangeln, abhängen. Aber dies ist unsere ursprüngliche Formulierung der weise, in der eine "Veränderung" der wirksame Grund für eine Unterscheidung werden kann.

7. Ein bestätigendes Experiment wird angegeben, in dem eingeschobene Tage des periodischen Bedingens gebraucht werden, um die verschiedenen Faktoren abzusondern, die an den Tagen der Umstellung wirksam sind.

8. Eine Kontrolle für einen möglichen Unterscheid in den Unterscheidungen zwischen $S_{AB...L...}$ und $S_{AB...}$ und umgekehrt wird beschrieben.

SKINNER